Layout and placement evolution

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FCC – a balance of stakes

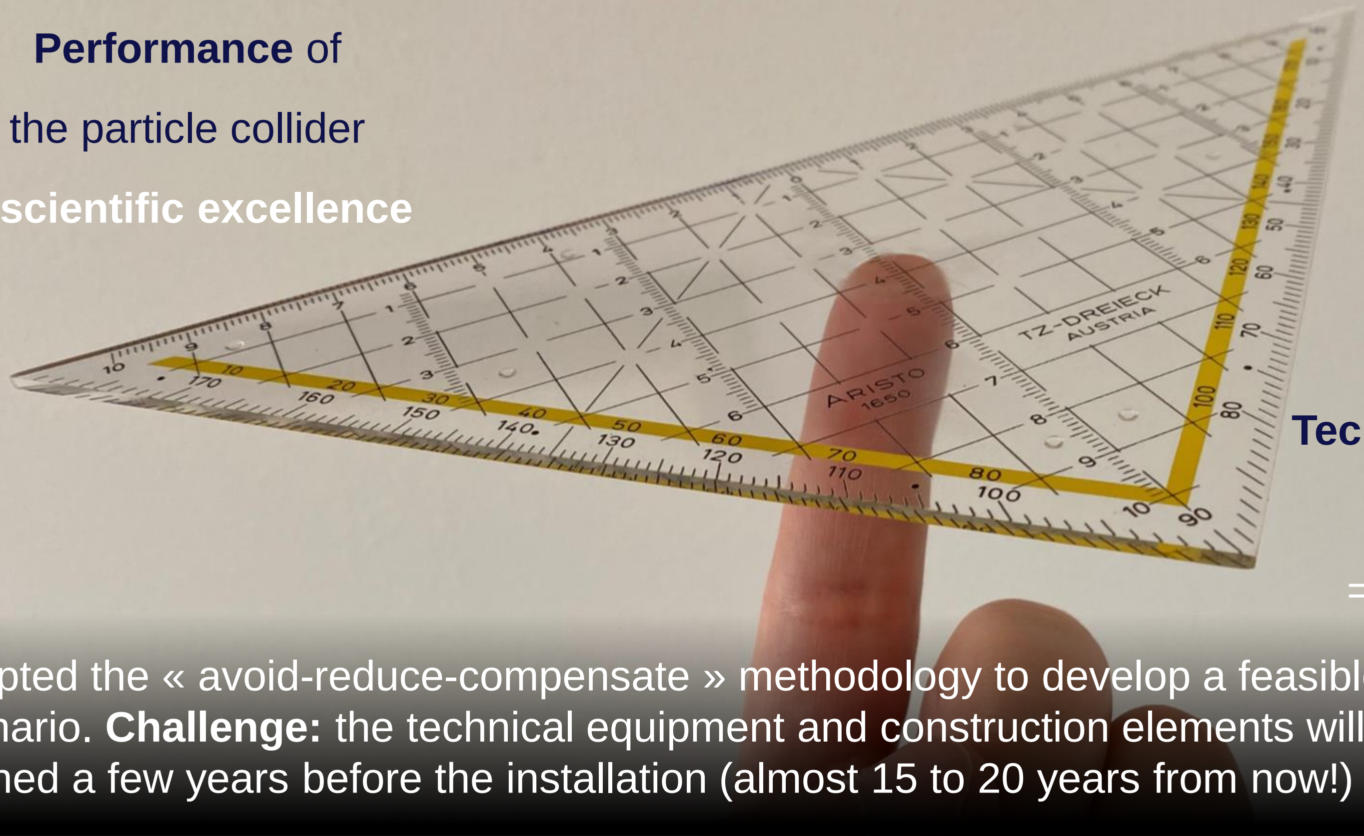
Territorial impacts

= **acceptability by society**

Performance of

the particle collider

= **scientific excellence**



Technical feasibility

and cost

= **project risks**

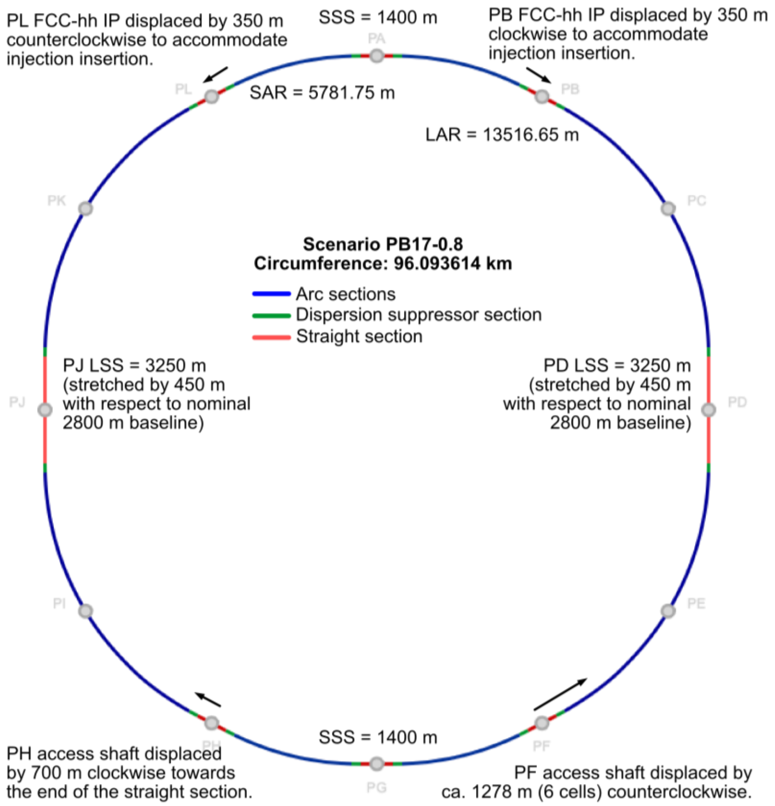
Adopted the « avoid-reduce-compensate » methodology to develop a feasible placement scenario. **Challenge:** the technical equipment and construction elements will only be reliably defined a few years before the installation (almost 15 to 20 years from now!) .

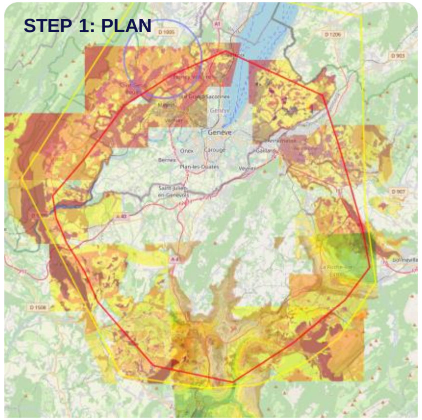
Evolution since CDR documentation baseline

CDR layout with 12 sites (97.75 km) turned out to have various drawbacks to serve as basis for a feasibility study.

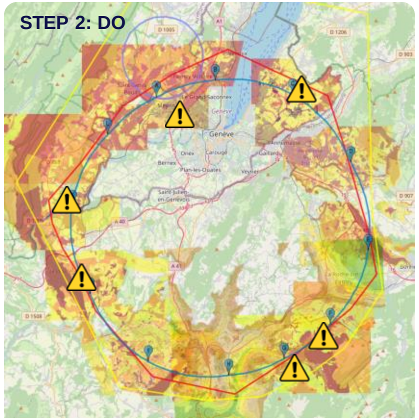
Conclusions after ~ 50 scenarios studied:

- Layout limited to 2 IPs for FCC-ee
- At the very limit with respect to the subsurface conditions known so far
- Straight sections artificially stretched
- 2 major site displacements due to deep shafts
- Challenging to find a scenario with surface areas that are sufficiently likely to be implementable from a territorial perspective





Identify the requirements and constraints for the technical and territorial aspects



Find a scenario that can meet the identified requirements and constraints.

Identify incompatibilities encountered.

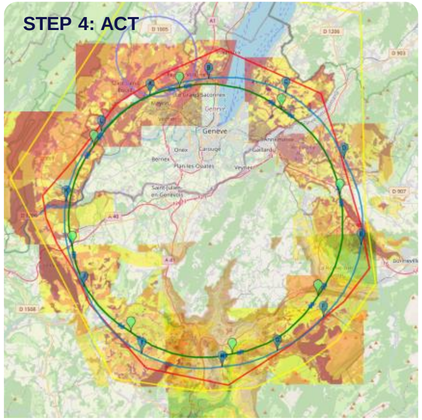
STEP 3: CHECK

	Territory	Layout	Cost & risk	Overall
CDR				
PB17				
Score	57	66	68	
PB19				
Score	74	33	25	
PA21				
Score	88	59	25	

Analyse the scenario

If it seems inacceptable, adjust it (step 4).

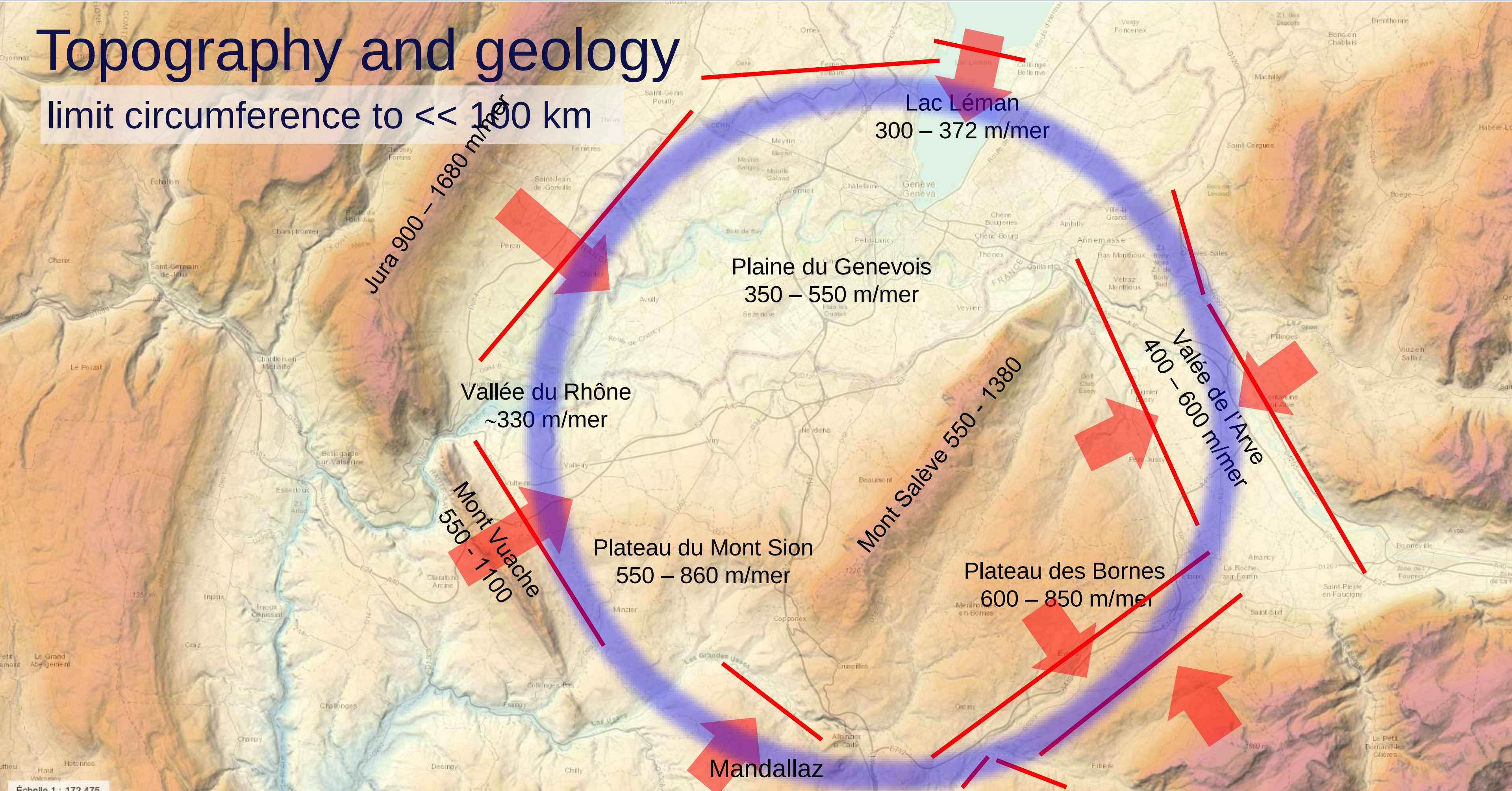
Otherwise, document it for further, in depth and detailed feasibility studies.



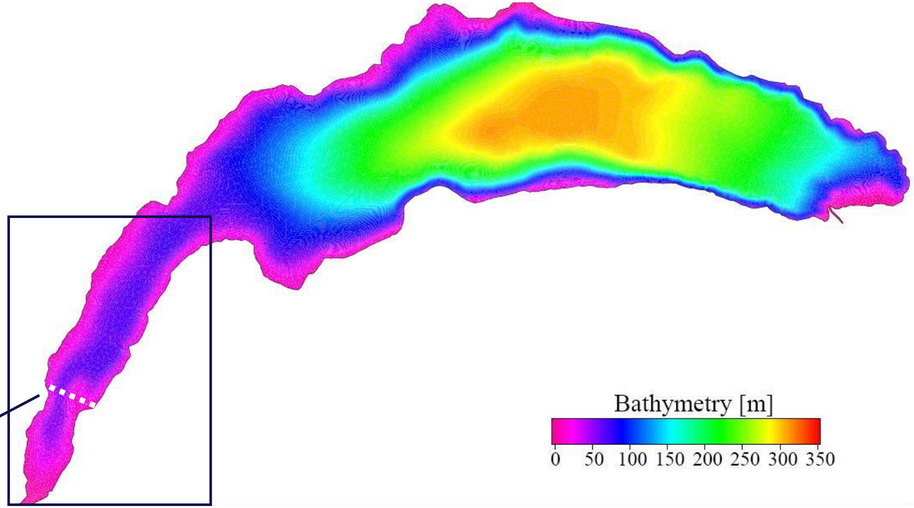
Conceive "avoid-reduce-compensate" measures to respond to the identified inacceptable elements identified in step 3.

Topography and geology

limit circumference to << 100 km



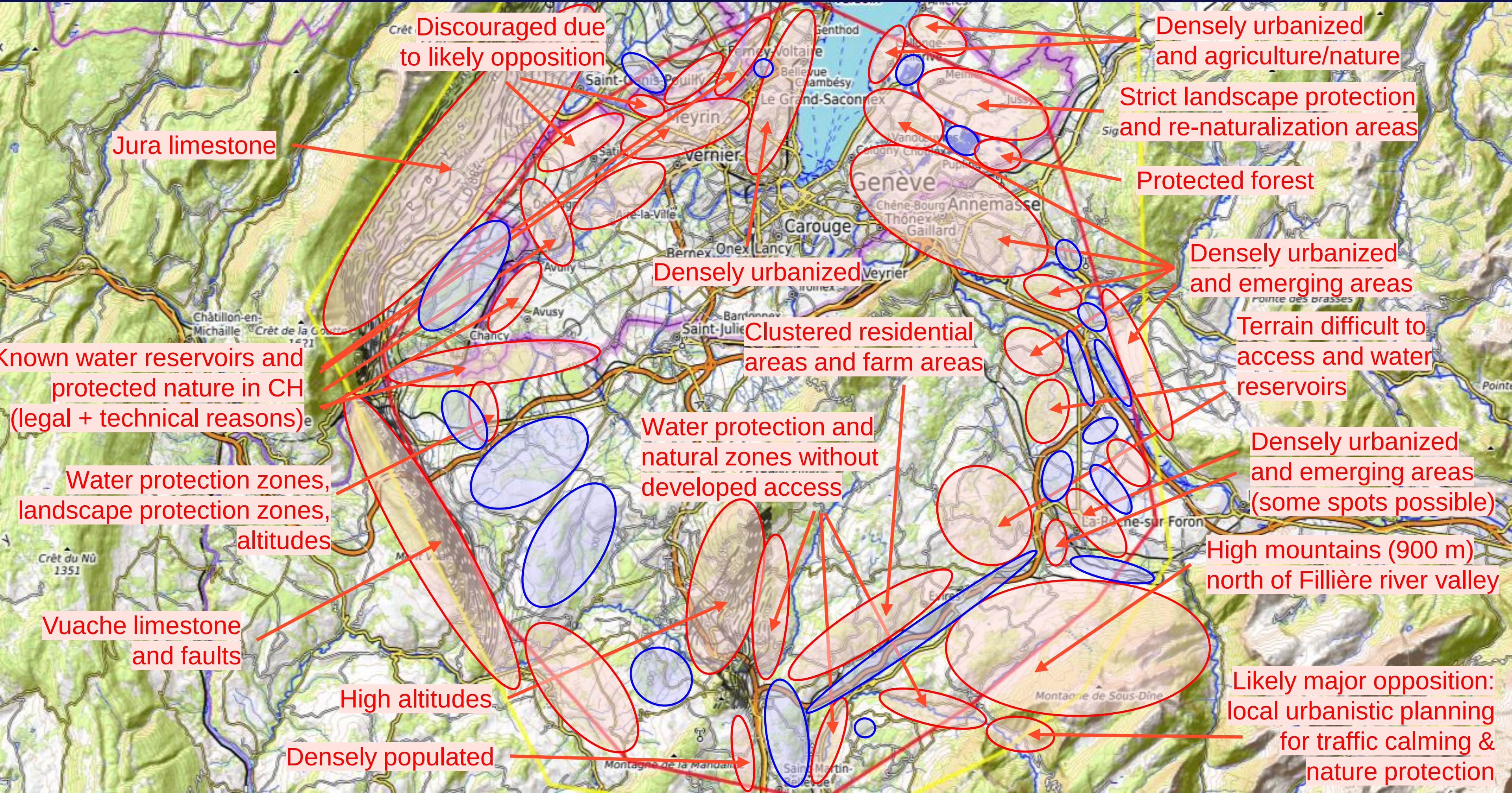
Lake depth



The lake is 50 m deep at the Versoix – Corsier line

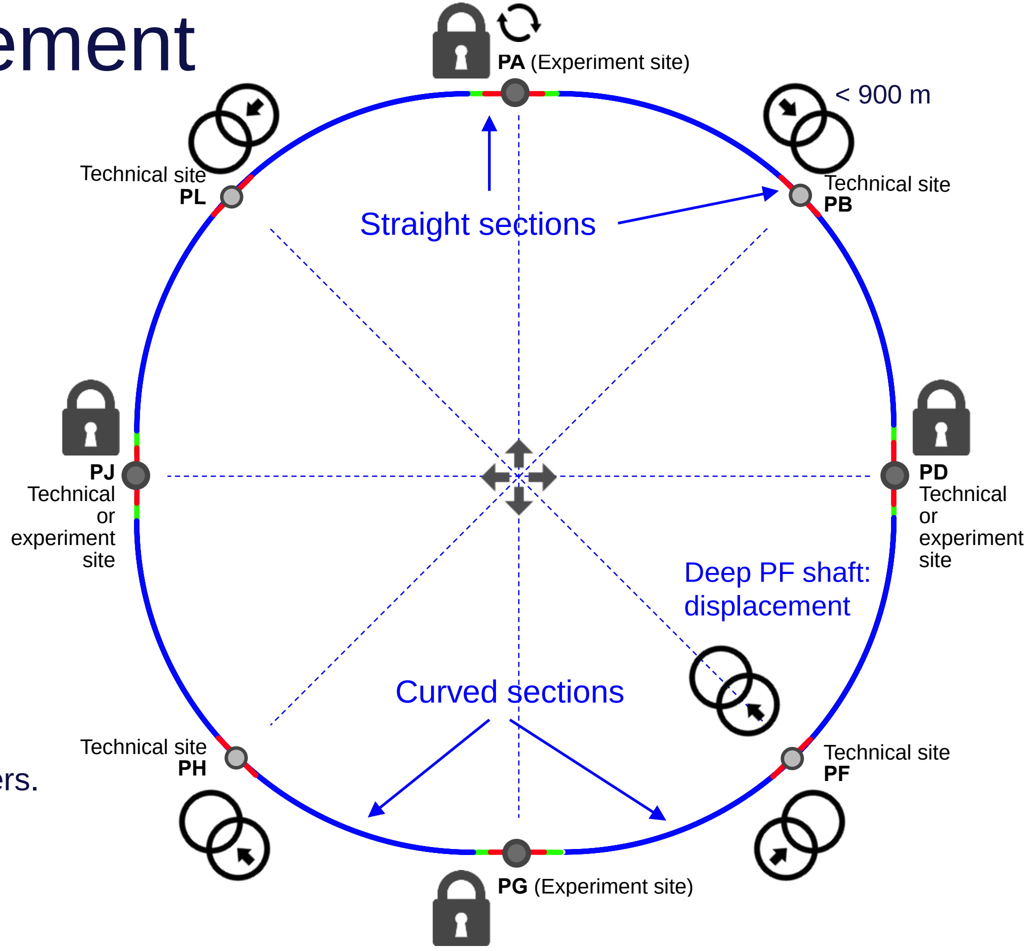
To avoid that the tunnel is too deep throughout the entire trace, the placement needs to remain south of this line.

It is preferrable to traverse the lake at the narrowest location to reduce the distance of instable ground and to limit risks linked to the presence of water.


Discouraged due to likely opposition
Densely urbanized and agriculture/nature
Strict landscape protection and re-naturalization areas
Jura limestone
Protected forest
Densely urbanized and emerging areas
Densely urbanized
Terrain difficult to access and water reservoirs
Known water reservoirs and protected nature in CH (legal + technical reasons)
Clustered residential areas and farm areas
Water protection and natural zones without developed access
Densely urbanized and emerging areas (some spots possible)
Water protection zones, landscape protection zones, altitudes
High mountains (900 m) north of Fillière river valley
Vuache limestone and faults
High altitudes
Likely major opposition: local urbanistic planning for traffic calming & nature protection
Densely populated
Genève
Annemasse
Carouge
Vernier
Meyrin

8-site layout and placement

- **Possibility for 2 or 4 IPs for FCC-ee**
- **Less site locations to find, but stricter geometry constraints at the 4 IP locations**
- **All site locations feature straight sections with specific functions that can be allocated**
- **Conclusions after ~50 scenarios studied:**
  - **Largest possible scenario** that is compatible with geological constraints known so far is **91 km** long
  - Shafts are not too deep. **Only PF requires** a horizontally **displaced access due to depth and accessibility** to the inside of the ring by ca. 400 m
  - Territorial compatibility seems achievable, but **map-based studies are exhausted**. Any further activity requires engagement with local actors and stakeholders.



Layout and placement review 7/8 June 2021

Participation of geology experts and subsurface construction companies to at least provide guidance on scenario classes with respect to construction risks.

2 representative scenarios showed significantly less civil engineering risks than all others: PA31, PA38

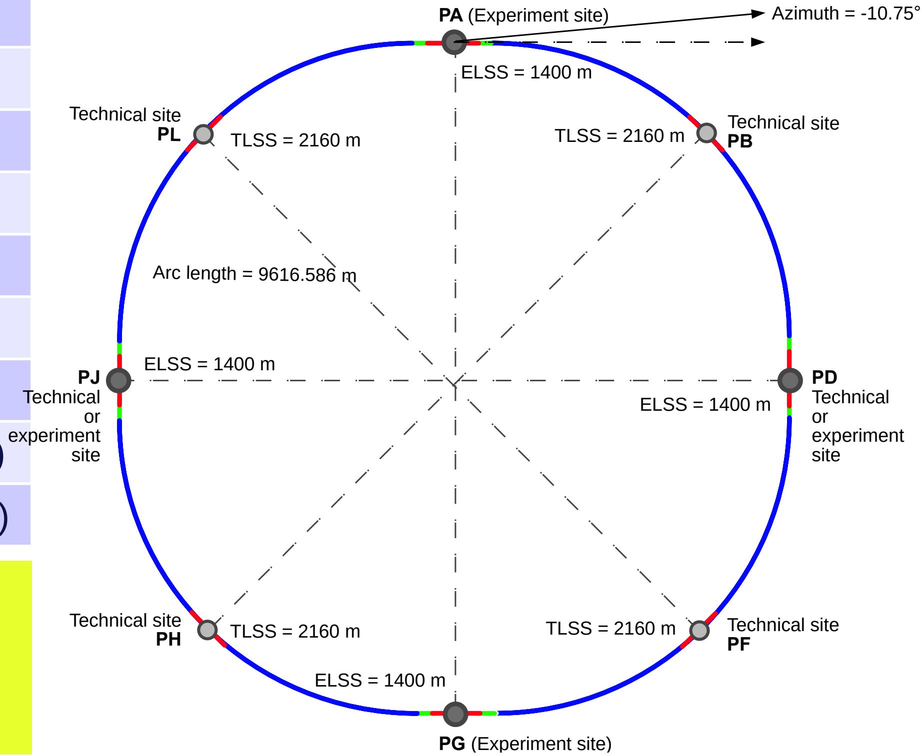
PA38 is a 89 km long scenario that has not beed further considered due to lower scientific performance and higher territorial challenges than PA31.

SECTOR	RISK	FINAL RISK INDEX							Std. Dev.*
		17-0.8	19-0.3	21-0.3	31-0.4	35-0.6	37-0.3	38-0.1	
LAKE	Quaternary soft ground, water bearing	47	28	54	29	65	79	40	20
ARVE	Quaternary soft ground, water bearing	12	4	9	6	6	4	5	3
MANDALLAZ	Limestone, water bearing karsts	96	96	96	96	96	96	96	0
USSES	Quaternary soft ground, water bearing	7	7	5	3	1	2	2	2
VUACHE	Limestone, water bearing karsts	24	442	240	12	50	12	12	16
RHONE	Quaternary soft ground, water bearing	18	5	8	11	8	11	12	4
JURA	Limestone, water bearing karsts	100	672	864	100	100	100	100	0
	TOTAL	304	1254	1276	257	326	303	267	29

Parameters of baseline scenario **PA31-1.0**

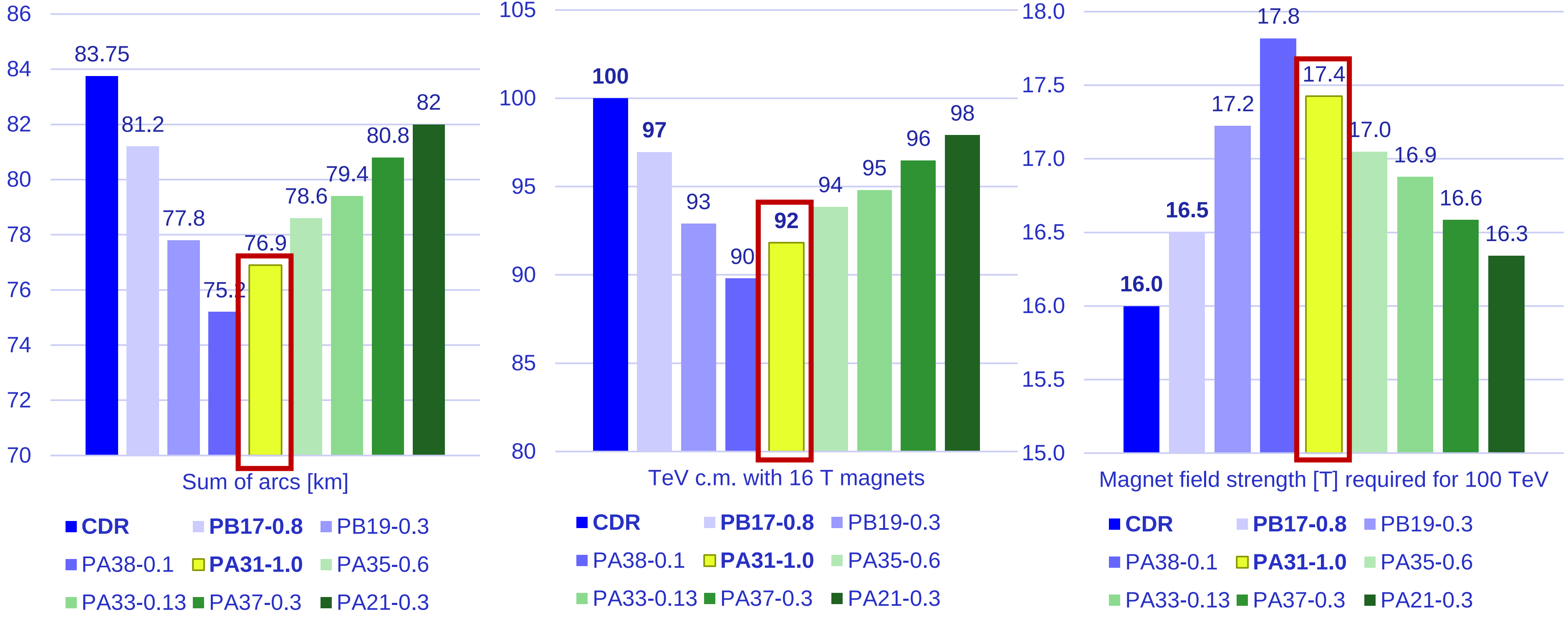
Number of surface sites	8
Number of arc cells	42 x 8
Arc cell length	213.045 m – 215.29 m
LSS@IP (PA, PD, PG, PJ)	1400 m
LSS@TECH (PB, PF, PH, PL)	2100 - 2160 m
Azimuth @ PA (0 = East)	-10.75° to -10.90°
Arc length	9.6 km (approximatively)
Sum of arc lengths	76.9 km (approximatively)
Total length	**91.1 km** (approximatively)

Caution! Values are evolving within limits until the placement report deliverable D3.3 is made available.



Note: Azimuth indicated by FFE tool with positive number is a counterclockwise rotation. By convention documented in the configuration management plan, as implemented in GIS environment it should be a negative number! Rotation is around origin (PA). Other tools still use the center point of layout.

FCC-hh c.m. energy reach for different arc lengths



Multi-Criteria Analysis (MCA)

Analysis and optimisation of placements with multi-criteria analysis for sites and one criteria list for the overall placement.

Land status
Plot availability
Clean and clear title to obtain rights on plot
Plot price
Time for acquisition
Cost of plot development
Connectivity
Distances from transport and infrastructures
Distance from populated areas
Raw materials and services
Availability of raw materials
Proximity to service providers
Infrastructure
Accessibility of electrical power
Communication networks
Water for industrial use
Drinking water
Sewerage disposal and treatment
Temporary storage areas during construction

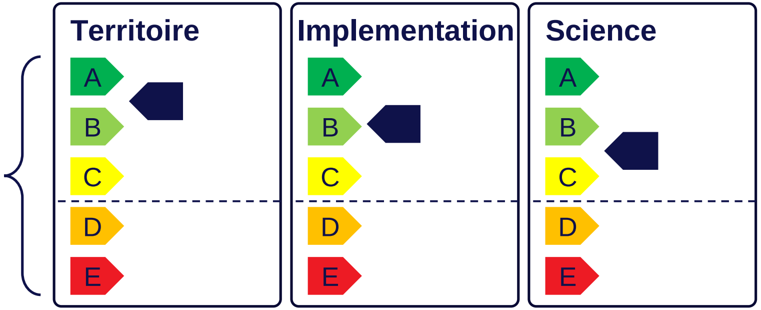
Physical features
Plot size and shape
Topography
Shaft depth
Drainage conditions
Surface ground conditions
Water resources
Accessibility
Physical subsurface conditions
Regulatory subsurface conditions
Environmental and social factors
Territorial constraints
Fauna and flora
Existing construction constraints
Adjacent surrounding constraints
Nuisances
Workforce availability and accessibility
Local government support
Civil society support

Overall layout
Geometry
Size
Transfer line compatibility
Project cost
Overall scenario cost
Project risk
Overall scenario implementation risk

Follows UNIDO best practice for planning “industrial type” installations

Multi criteria analysis summary with 3 pillars

Normalised criteria on scale between 0 % et 100 %



Score and feasibility conditions

- A 85 - 100: Feasible with minor adjustments or efforts
- B 70 - 84: Feasible with moderate adjustments or efforts
- C 55 - 69: Feasible with major adjustments or efforts
- D 40 – 54: Feasibility **remote**
- E 0 - 39: Feasibility **improbable**

Below acceptance threshold

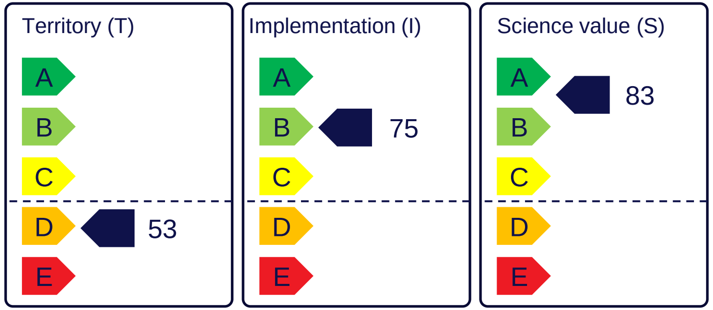
Summary of **territorial stakes**

Summary of **construction-related stakes**

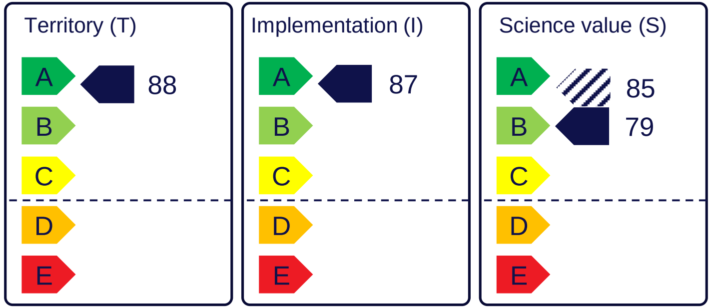
Summary of criteria that relate to the **performance** required **to carry out the foreseen scientific research programme**

Multi-criteria analysis: CDR PA0 vs. PA31

CDR (Berlin 2017 baseline)



PA31 (June 2021 baseline)



Value for science is lower than the CDR baseline with 2 experiment in phase 1 (FCC-ee) due to the smaller overall arc lengths. With 2 experiments in phase 1, the value for science is higher. This configuration provides more room for energy and resource saving by maintaining or even exceeding the initially foreseen scientific output.

Site by site comparison PA0 vs. PA31

PA0	PA	PB	PC	PD	PE	PF	PG	PH	PI	PJ	PK	PL	Trace	Total
FCC-ee	EXP			RF			EXP			RF			**97.75 km**	
FCC-hh	EXP	EXP	Cryo		Cryo	Col		RF	Cryo	Col	Cryo	EXP		
Site														
Score	89	52	51	61	75	40	41	36	49	45	33	36	**84**	**53**

PA31	PA	PB	-	PD	-	PF	PG	PH	-	PJ	-	PL	Trace	Total
FCC-ee	EXP	Tec		Tec		Tec	EXP	RF		Tec		RF	**91.1 km**	
FCC-hh	EXP	Cryo		EXP		Cryo	EXP	Cryo		EXP		Cryo		
Site														
Score	84	73	-	86	-	79	79	84	-	71	-	71	**82**	79

Advantages/disadvantages of new baseline

PROS:

8 sites **use less land** (36 ha vs. 62 ha)

Possibility for 4 FCC-ee **experiment** sites

All sites **close to road infrastructures** (3.5 km of road constructions needed for all sites)

RF sites **close to 400 kV grid lines**

PA **profits from LHC Pt8 infrastructures** and main CERN cooling water supply line

Less excavated materials

Good connection of PD, PF, PG, PH **to Annecy** putting IN2P3/LAPP in the position to acts as a second pole for design, construction and operation.

CONS:

Smaller (91 km vs. 98 km)

Longer distance between sites generates different requirements and constraints for technical infrastructures (water supply, electricity, cryogenics, tunnel transport)

Only a **single shaft to experiment** cavern

Some technical shafts are displaced along the ring

Deepest shaft at **PF (400 m) requires a horizontal connection** tunnel to the ring at the bottom of the shaft (400 m long).

Ongoing and next activities

Engagement with local stakeholders
- understand in principle feasibility of targeted surface site candidate areas
- identify potential conflicts with planned or in construction projects in France and in Switzerland (e.g. roads, railways, commercial and economic activity areas, schools, hospitals, residential housing, and many more)

Identify potential locations to access the 400 kV national electricity grid

Identify potential sources for cooling water

Optimise surface site locations according to the “avoid-reduce-compensate” approach

Highway access feasibility study (carried out by Cerema)

Railway terminal use, refurbishment or creation **study** (call for tender open)

Identification of mines and quarries for backfill opportunities (done by SETEC for 2 departments, one department and Switzerland to be added later this year)

Agricultural study to determine economic value and losss of required land

Environmental and urbanistic initial state analysis (call for tender open)

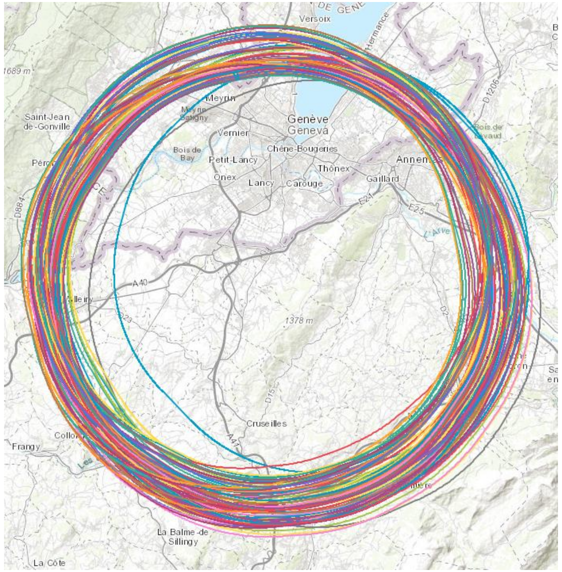
Conclusions

~ 100 12- and 8- site scenarios were looked at using map-based analysis.

A working hypothesis has been selected as workhorse for in-detail feasibility condition identification.

The 91 km long scenario **PA31 so far seems to be**

- **suitable to meet the scientific performance** needs.
- **compatible with subsurface constraints,** but geophysical and geotechnical investigations are urgently needed for areas where data is insufficient,
- **the most suited scenario** among all scenarios looked at **from a territorial point of view,**



CAUTION: the baseline is not yet discussed with local elected representatives of the population and not with affected local stakeholders. This is a risk! Usually, detailed studies are only engaged, once in principle feedback about acceptability is obtained. By law, stakeholders must also be engaged in the choice. We have requested the launch of the process, but we need and rely on host state support for this type of activity.